= 12) and contained all of the organelles and inclusion bodies characteristic of a species of *Sarcocystis* (Dubey et al., 1989). Rhoptries were absent (Fig. 16).

The parasite in the raccoon was not *T. gondii* or *N. caninum* because it divided by endopolygeny, was not located in a parasitophorous vacuole, and did not react with antisera against *T. gondii* and *N. caninum* in an immunohistochemical test (Dubey et al., 1990). Structurally, the raccoon parasite appears identical with the newly named organism, *Sarcocystis neurona* Dubey, Davis, Speer, Bowman, de Lahunta, Granstrom, Topper, Hamir, Cummings, and Suter, 1991, that causes fatal neurological disease in horses (Fayer and Dubey, 1987; Dubey et al., 1989, 1991).

The life cycle of *S. neurona* is not known. Only schizonts in the central nervous system of horses have been found. *Sarcocystis neurona* was recently grown in bovine monocytes in culture (Dubey et al., 1991). Further studies in the raccoon and with cultured organisms might help elucidate the life cycle of these parasites that cause encephalomyelitis in animals.

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Research Note

Helminth Parasites from Some Tichigan Lake Fishes in Southeast Wisconsin

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ABSTRACT: A total of 2,525 fishes of 30 species from Tichigan Lake and associated waters (Racine County) was examined for parasites between 1977 and 1979. *Corallobothrium fimbriatum, C. giganteum, Ophiotaenia fragilis, Proteocephalus* sp. (Cestoda), and *Polylekithum ictaluri* (Trematoda) are reported from *Ictalurus punctatus*, and *Triaenophorus nodulosus* plerocecoids from *Catostomus commersoni*. All records are new to southeastern Wisconsin. Channel catfish appeared to be the major host of *C. giganteum*. *Corallobothrium* recruitment occurred during all seasons, but was maximal during autumn. Development, maturation, prevalence, and intensity of infection increased during spring and summer. Infection with *Corallobothrium* was not associated with host sex or size; no posterior migration was observed. The white sucker appears to be the more common host of *T. nodulosus* in North America. The seasonality of *Acanthocephalus dirus* (Acanthocephala) in 9 common fish hosts was similar to that of *Corallobothrium*. Infections in 1977–1979 were, however, very light and fecundity unusually low. The spring population was compared with those from other years, e.g., 1984, and from a riverine habitat, the Pike River.

KEY WORDS: Wisconsin, catfish, *Corallobothrium, Ophiotaenia, Proteocephalus, Polylekithum, Triaenophorus, Acanthocephalus*, seasonality, host size and sex, site selection.

The seasonal ecology of cestode parasites of catfish, and of *Acanthocephalus dirus* from 9 fish

species in Tichigan Lake, Racine County, Wisconsin, are reported here for the first time. The seasonality of *A. dirus* has not been previously reported in a lake situation. Cestodes and trematodes were commonly reported from catfish in Wisconsin (Fischthal, 1947; Anthony, 1963) and elsewhere (Bangham and Hunter, 1939; Bangham, 1940, 1972; Bangham and Venard, 1942), but are recorded in southeastern Wisconsin for the first time.

Fishes were collected from Tichigan Lake (Racine County), a 458-ha lake in an advanced state of eutrophication on the Fox River (tributary of the Mississippi River). Seasonal biweekly collections were made during spring (April), summer (June, July, and early August), and autumn (late October and November) between 1977 and 1979. A total of 982 fishes representing 29 species and 10 families was captured by electroshocking. An additional 1,543 fishes representing 27 species and 11 families were collected in a channel draining the swampy western area of Tichigan Lake using seines or minnow traps (see Amin, 1990, for more details).

Fish were systematically dissected shortly after capture. Cestodes were fixed, stained, and mounted as in Amin (1990) and categorized as juveniles (small, proglottids immature or not yet formed, scolex not fully developed), adults (posterior proglottids sexually mature), and gravid (at least some proglottids with eggs). The trematode and acanthocephalan parasites were processed as in Amin, 1982 and 1987, respectively. Means refer to number of worms recovered/number of fish examined. Representative specimens were deposited in the U.S. National Museum Helminthological Collection (USNM Helm. Coll.) and in the University of Nebraska State Museum Harold W. Manter Laboratory Collection (HWML Coll.) as follows:

Corallobothrium giganteum Essex, 1927: USNM Helm. Coll. Nos. 81487–81491; HWML Coll. Nos. 31624–31627. *Corallobothrium fimbriatum* Essex, 1927: USNM Helm. Coll. No. 81486; HWML Coll. No. 31623. *Trianophorus nodulosus* Pallas, 1760: USNM Helm. Coll. No. 81485; HWML Coll. No. 31622. *Acanthocephalus dirus* (Van Cleve, 1931) Van Cleave and Townsend, 1936: USNM Helm. Coll. Nos. 79791–79798.

A total of 209 *Corallobothrium giganteum* and 44 *C. fimbriatum* was recovered from 20 and 7 channel catfish, *Ictalurus punctatus*, respectively, from Tichigan Lake proper. Fishes were more frequently and heavily infected with *C. giganteum* (prevalence, 57%; mean intensity, 6.0) than with *C. fimbriatum* (20%; 1.3) (Table 1). This suggests that channel catfish is the more optimum definitive host of the first rather than the latter cestode species. Most previous reports indicate *C. giganteum* infections in *I. punctatus* and *C. fimbriatum* in other species of *Ictalurus* (Bangham and Hunter, 1939; Bangham, 1940, 1972; Bangham and Venard, 1942; Anthony, 1963). Recruitment of *C. giganteum* occurred during all seasons but was maximal (highest prevalence of juveniles) during autumn. Development, maturation, prevalence, and intensity of infection generally increased during spring and summer. The seasonality of *C. fimbriatum* was somewhat similar to that of *C. giganteum* except for its decreased maturation in *I. punctatus*; no gravid worms were recovered (Table 1). This observed seasonality agrees with the patterns reported for both cestode species in *I. punctatus* from the Rock, Mississippi, and Illinois rivers by Essex (1928), from Lake Carl Blackwell, Oklahoma, by Spall and Summerfelt (1969), and from the Kentucky and Ohio rivers by Edwards et al. (1977). Haderlie (1953) also observed similar seasonality of *C. fimbriatum* in *Ictalurus nebulosus* and *C. giganteum* in *Ictalurus catus* from Clear Lake, California. Gruninger et al. (1977), however, observed no seasonality in numbers of *C. fimbriatum* from *I. punctatus* in Eagle Mountain Lake, Texas. No relationship with host size or sex was observed. This is contrasted with the observations of Haderlie (1953) in California and Hoffnagle et al. (1990) in Tennessee. The differences in these findings may be related to the considerable diversity in the omnivorous channel catfish diet which was noted by Cannamella et al. (1978) to vary with forage availability, geographic location, and relative abundance and age of catfish. There was no evidence of seasonal posterior migration of *Corallobothrium*; the proportion of both species was highest in the small intestine directly behind the stomach during autumn (61%), spring (54%), and summer (72%). The remainder of the worms were located in decreasing frequencies in more posterior intestinal regions. The 7 *I. punctatus* infected with *C. fimbriatum* were also concurrently infected with *C. giganteum*; they were not spatially segregated. Haderlie (1953) reported anterior intestinal localization of *C. fimbriatum* in *I. nebulosus* but middle and posterior gut sites for *C. giganteum* in *I. catus*.

Table 1. Prevalence, mean intensity, and seasonal development of *Corallobothrium fimbriatum* and *C. giganteum* in *Ictalurus punctatus* from Tichigan Lake, 1977–1979.

	Autumn (late Oct., Nov.)	Spring (April)	Summer (June–early Aug.)	Total
Corallobothrium fimbriatum				
No. of cestodes (mean/fish) max.	0	16 (1.0) 14	28 (2.3) 22	44 (1.3) 22
Fish infected/examined (%)	0/6	2/17 (12)	5/12 (42)	7/35 (20)
% juvenile, mature, gravid cestodes	—	94, 6, 0	82, 18, 0	86, 14, 0
Corallobothrium giganteum				
No. of cestodes (mean/fish) max.	18 (3.0) 8	64 (3.8) 26	127 (10.6) 46	209 (6.0) 46
Fish infected/examined (%)	4/6 (67)	7/17 (41)	9/12 (75)	20/35 (57)
% juvenile, mature, gravid cestodes	89, 0, 11	58, 42, 0	22, 20, 58	39, 25, 36

One of 3 channel catfish examined from Tichigan Lake Canal was also infected with 14 gravid *C. giganteum* and 3 mature *C. fimbriatum* in May 1979. One of 5 yellow bullhead, *Ictalurus natalis,* examined also from Tichigan Lake Canal was infected with 1 mature *C. fimbriatum* in June 1978. An additional *C. fimbriatum* adult was recovered from 1 of 4 *I. natalis* in Silver Lake, a 188-ha land-locked eutrophic lake in adjacent Kenosha County. The absence of *C. giganteum* from Silver Lake is attributed to the absence of its major host, channel catfish, from that lake.

Three juvenile *Ophiotaenia fragilis* Essex, 1929, were recovered from a 50-cm long female *I. punctatus* in Tichigan Lake proper during spring 1977. The fish was also infected with 26 *C. giganteum* and 2 *C. fimbriatum.*

Six *Triaenophorus nodulosus* plerocercoids were coiled in 5 intestinal nodules recovered from 3 white suckers, *Catostomus commersoni,* in Tichigan Lake proper (3 worms from 2 suckers in July and October 1978), and Tichigan Lake Canal (3 worms from 1 sucker in May 1979). A total of 54 and 11 white suckers were examined from each location, respectively. Of the 85 species of fish intermediate hosts of *T. nodulosus* (see Valtonen et al., 1989), 24 species are reported from North America (Kuperman, 1973). In Europe, the preferred host appears to be perch (Andrews, 1979; Scholz, 1987; Ieshko et al., 1989). None of 77 yellow perch, *Perca flavescens,* examined from Tichigan Lake was infected. The white sucker appears to be the common host in North America and has often been infected when *P. flavescens* sampled from the same waters were free from infection (Fischthal, 1950, 1952).

One cestode of an undetermined species of *Proteocephalus* was found in the intestine of a channel catfish from Tichigan Lake Canal in July 1979.

One gravid trematode, *Polylekithum ictaluri* (Pearse, 1924) Arnold, 1934 (=*Allocreadium ictaluri* Pearse, 1924; *A. halli* Mueller and Van Cleave, 1932), was found in the intestine of a 46-cm-long male channel catfish from Tichigan Lake proper during autumn 1979. The specimen fit the descriptions given by Pearse (1924), Mueller and Van Cleave (1932), and Arnold (1934). The vitellaria in my specimen and Pearse's (1924) material, also from Wisconsin, were discontinuous at the level of the acetabulum. Those in Mueller and Van Cleave's (1932) and Arnold's (1934) material from New York were, however, continuous.

Records of *Acanthocephalus dirus* in 16 fish species and 7 families from Tichigan Lake were listed in Amin (1985). The seasonal distribution of adult *A. dirus* from 9 common fish species collected in 1977–1978 is indicated in Table 2. The spring collection was compared with another from the same host species during the same season in 1984. The size of fishes of the same species from both spring collections was similar. The seasonal pattern of *A. dirus* during 1977–1978 was characterized by low infection intensities, slow development, low fecundity, and early elimination (none was recovered in the summer) compared to the 1984 spring pattern or the pattern in a river setting (Amin, 1975). There was no unusual weather condition noted for 1977–1978. Seasonal collections of other helminths from the same lake during the same period were not unusual. The 1977–1978 pattern was not evident in subsequent collections. For example, the 1984 spring distribution of *A. dirus* (the usual peak breeding season with maximum intensity)

Table 2. Seasonality of adult *Acanthocephalus dirus* from common fish hosts in Tichigan Lake during 1977 and 1978 compared with spring distribution in 1984.

	1977, 1978							1984		
	Autumn (Oct., Nov.)			Spring (April)			Summer (July, Aug.)	Spring (April)		
	Fish	*Acanthocephalus dirus*		Fish	*Acanthocephalus dirus*		Fish	Fish	*Acanthocephalus dirus*	
Fish species	Inf./exam. (%)	Total (mean/fish*)	% ♀ with eggs (with plugs)	Inf./exam. (%)	Total (mean/fish)	% ♀ with eggs (with plugs)	Inf./exam.	Inf./exam. (%)	Total (mean/fish*)	% ♀ with eggs (with plugs)
Catostomidae										
Catostomus commersoni	4/25 (16)	25 (1.00)	0 (0)	0/4 (0)	—	—	0/25	14/14 (100)	727 (51.93)	47 (13)
Centrarchidae										
Lepomis cyanellus	1/6 (17)	1 (0.17)	—	5/7 (71)	48 (6.86)	4 (48)	0/5	0/0 (0)	—	—
Lepomis gibbosus	0/13 (0)	—	—	9/15 (60)	67 (4.47)	3 (35)	0/32	1/1 (100)	4 (4.00)	0 (1)
Lepomis macrochirus	1/87 (1)	2 (0.02)	0 (0)	12/51 (23)	66 (1.29)	0 (5)	0/74	15/23 (65)	82 (3.56)	10 (29)
Micropterus salmoides	0/23 (0)	—	—	0/2 (0)	—	—	0/19	11/12 (92)	50 (4.17)	4 (22)
Pomoxis nigromaculatus	1/59 (2)	1 (0.02)	—	2/70 (3)	3 (0.04)	0 (0)	0/33	3/13 (23)	6 (0.46)	0 (0)
Cyprinidae										
Cyprinus carpio	0/30 (0)	—	—	0/14 (0)	6 (0.43)	0 (0)	0/22	4/5 (80)	78 (15.60)	10 (38)
Ictaluridae										
Ictalurus natalis	0/0 (0)	—	—	6/7 (86)	209 (29.86)	0 (29)	0/1	8/8 (100)	171 (21.37)	2 (55)
Percidae										
Perca flavescens	0/17 (0)	—	—	15/57 (26)	20 (0.35)	0 (0)	0/3	5/68 (7)	17 (0.25)	14 (43)
Total	7/260 (3)	29 (0.11)	0 (0)	49/227 (22)	419 (1.84)	1 (20)	0/214 (0)	61/144 (42)	1,135 (7.88)	34 (22)

* Mean = number of worms recovered/number of fishes examined.

shows considerably higher prevalence (42%), mean intensity (7.88), and fecundity (34% of females with eggs) compared to the spring of 1977–1978 in the same fish species (22%, 1.84, 1%) (Table 2). Whether *A. dirus* undergoes annual cycles in fecundity and abundance is unknown. Changes in *A. dirus* populations at the intermediate host level could be involved, but these could hardly explain differences in seasonal maturity and fecundity. Intestinal distribution of *A. dirus* in fish hosts during the spring of 1977–1978 was more anteriad than what is normally found in fish infected with breeding worms during the spring (Amin, 1975). This suggests that posterior migration of acanthocephalans is more closely associated with worm maturation than with season.

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Research Note

First Report of *Ostertagia leptospicularis* (Nematoda: Trichostrongyloidea) in Calves (*Bos taurus*) from North America[1]

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ABSTRACT: Specimens of *Ostertagia leptospicularis* were recovered from abomasa of 17 of 23 naturally infected calves in Oregon. Also present were: *Ostertagia kolchida, Ostertagia lyrata,* and *Ostertagia ostertagi.* The co-occurrence of specific pairs of species (*O. leptospicularis: O. kolchida,* and *O. ostertagi: O. lyrata*) supports the hypothesis of polymorphic species pairs within the Ostertagiinae. This is the first report of *O. leptospicularis* and the second of *O. kolchida* in cattle from North America.

KEY WORDS: Oregon, *Ostertagia leptospicularis*, Nematoda

Ostertagia leptospicularis Asadov, 1953, is a common abomasal parasite of members of the Cervidae and has been found in the abomasum of other sylvatic and domestic ruminants. The known geographic range of *O. leptospicularis* has until recently been confined to the Palearctic region and New Zealand where it is considered to be fairly common in cervids and less common in cattle. Common hosts include elk, *Cervus elaphus* (Jansen, 1960; Drozdz, 1966; Kutzer and Hinaidy, 1969; Dunn, 1983), moose, *Alces alces* (Drozdz, 1966; Nilsson, 1971), sika deer, *Cervus nippon* (Drozdz, 1966), fallow deer, *Cervus dama* (Swierstra et al., 1959; Drozdz, 1966), roe deer, *Capreolus capreolus* (Swierstra et al., 1959; Dunn, 1965; Drozdz, 1966; Kutzer and Hinaidy, 1969; Nilsson, 1971; Andrews et al., 1974; Drozdz et al., 1987), chamois, *Rupricapra rupricapra* (Kutzer and Hinaidy, 1969), caribou, *Rangifer tarandus* (Freutel and Lankester, 1989), cattle, *Bos taurus* (Rose, 1963, 1968; Hinaidy et al., 1972), and sheep, *Ovis aries* (Swierstra et al., 1959; Nilsson, 1971).

The data presented in this report support the hypothesis of polymorphism suggested by Lancaster and Hong (1981). A report by Lichtenfels et al. (1988) also supports this hypothesis and provides a redescription of 7 species of the Ostertagiinae that are considered to be polymorphs of only 3 species, with each species pair being morphological variants of a single species. Between each polymorphic species pair, the major and minor species are usually found together, with 1 partner always dominant. An exception to this was reported by Rickard and Zimmerman (1986) when *O. kolchida* was discovered in the absence of its major species, *O. leptospicularis.*

The recovery of *O. leptospicularis* and *O. kolchida* during the present study represents the first report of *O. leptospicularis,* and the second of *O. kolchida,* from cattle in North America. The first report of *O. kolchida* from North America was by Rickard and Zimmerman (1986) in cattle from Oregon. Freutel and Lankester (1989) reported the recovery of *O. leptospicularis* from captive caribou at the Kakabeka Falls Game Farm, Canada, representing the first report from North America. Lichtenfels et al. (1988) listed *O. leptospicularis* from California cattle in a table of specimens studied, but we have learned (Lichtenfels, pers. comm.) that the item was a typo-

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